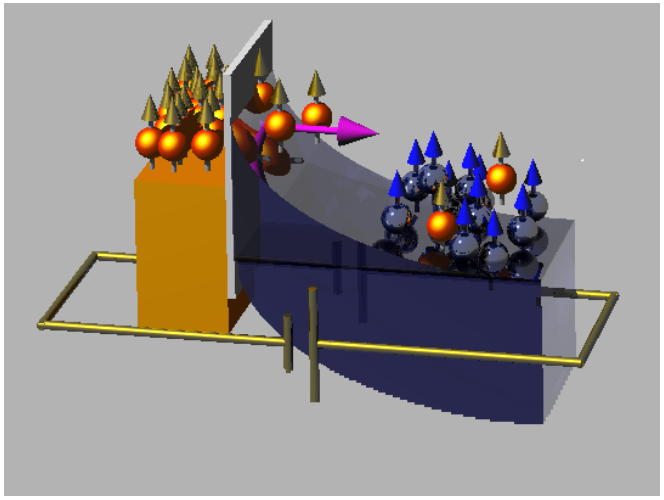
# Spintronics and Information Technology

UNIVERSITY OF MINNESOTA
Materials Research Science and Engineering Center
DMR-0212302

## *An Electronic Pump for Nuclear Spins*

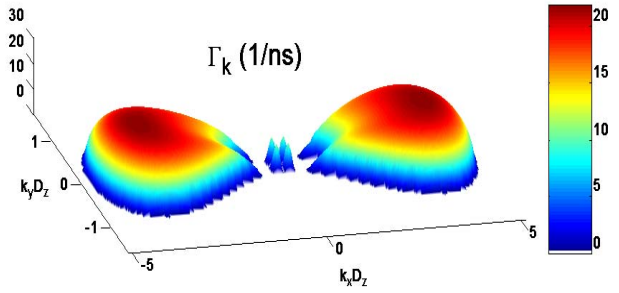
The Magnetic Heterostructures IRG at the University of Minnesota has designed a spin-based storage information device that combines a material ordinarily used for information storage (iron) with a common semiconductor (gallium arsenide). This represents a significant advance because the electron spin - the property that carries information - is retained when it passes into the semiconductor. Ordinarily this information, often referred to as spin polarization, would decay in roughly one-billionth of a second. In this new device, however, the electrons transfer their spin to the nuclei that form the cores of atoms in the semiconductor. Unlike the electrons, the nuclei can retain their spin for many minutes, after which their spin can be read by electrons. This type of read/write device could enable nuclear spin to be used as a processing element in computers [J. Strand, B. D. Schultz, A. F. Isakovic, C. J. Palmstrom, and P. A. Crowell, *Phys. Rev. Lett*. **91**, 036602 (2003)].



Spin-polarized electrons (orange spheres) tunnel through the barrier separating ferromagnetic iron (orange) from a semiconductor (gray). Once inside the semiconductor, the electrons transfer their spin to nuclei (gray spheres).

## *Ultrafast magnetic switching*

In a computer hard drive, information is written by changing the magnetic orientation of small grains of material. In state-of-the-art applications, this process occurs within approximately one nanosecond. One of the obstacles to faster magnetic switching is the tendency for the magnetic orientation to oscillate back and forth after the grains are switched, similar to the swinging of an abruptly closed saloon door. Whereas friction provided by its hinges reduces the swinging of a door, the “friction” in a magnetic film is provided by microscopic processes such as atomic vibrations. Using a combination of calculations and computer simulations, the Magnetic Heterostructures IRG discovered that the decay of the oscillations following abrupt magnetic switching is faster than if the magnetic orientation is tilted by only a small angle. It is as if a door that is slammed quickly stops swinging sooner than one that is bumped gently. This promises to make sub-nanosecond magnetic switching easier to achieve [A. Yu. Dobin and R.H. Victora, *Phys. Rev. Lett.* **90**, 167203 (2003)].




Bright regions correspond to excitations that help to remove energy during an ultrafast magnetic switching process. These excitations provide the damping that keeps the magnetization of a grain from oscillating back and forth after it is switched.

# University of Minnesota
## Materials Research Science and Engineering Center

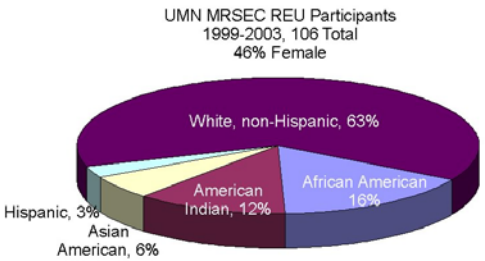
Frank Snowden, Associate Director of Education and Human Resources
Dawn Lippman, Assistant

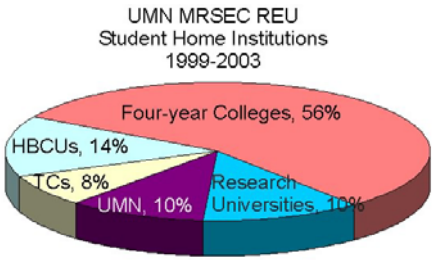
### Education

- A network of more than 140 four-year colleges, tribal colleges (TCs), and historically black colleges and universities (HBCUs) through cooperative agreements
- Summer research experiences for visiting faculty-student teams and individual undergraduate students

### Since inception of the UMN MRSEC

- Students from under-represented groups: 33%
- Women: 44%
- Student participants from four-year colleges,TCs and HBCUs combined: 78%
- These levels sustained in Y2003




### Outreach in Y2003

- Three tribal college participants
- *Physics Force* shows for 10,000 urban K-6 students and road shows at two tribal colleges (UMN faculty peforming fun physics demonstrations)
- Three urban high school teachers (RET)
- Frank Snowden: Member, NSF Planning Grant Advisory Board of the College of Menominee Nation
- Submitted joint PREM grant proposal with College of Menominee Nation

MRSEC faculty investigator David Norris with Nagalingam Balakrishnan and Dan Husby (from College of Menominee Nation)

(left to right) Bill Van Lopik (CMN), Mike Ward (UMN MRSEC Director), Holly Youngbear-Tibbets (CM□N), Frank Snowden, and Melissa Cook (CMN) at College of Menominee Nation, with the Bear representing one of five Clans of the Menominee people.

UMN MRSEC: DMR-0212302
REU/RET SITE: DMR-02435489